Environment, Health & Safety Division

September 12, 2000
RPG-00-088

To: Duffy & Dougherty, LLC

From: Gary H. Zeman, LBNL Radiation Control Manager, Environment, Health & Safety Division

Subject: Information Requested by CMTW on 9-8-00

This replies to the memo you received from Committee to Minimize Toxic Waste dated 9-8-00 requesting information related to the Environmental Sampling Task Force. The information requested was in three areas, namely potential consequences of fire, landslide or earthquake events on the National Tritium Labelling Facility (NTLF); tritium inventory information; and tritium measurement information.

The potential consequences of various accident scenarios, including fire, landslide and earthquake, were addressed in the 1996 Safety Analysis Document (SAD) for the NTLF. Attachment A contains a brief summary of that information, and shows that even in the worst case scenario of complete release of the NTLF tritium inventory in a catastrophic wild land fire, the radiation dose to members of the public would be small.

Detailed information on tritium inventory and accountability procedures at Berkeley Lab was provided earlier this year to Mr. Bernd Franke as part of the City of Berkeley's environmental review. That information was made available to CMTW and other citizens. Attachment B summarizes that information, and brings it up to date with regard to inventory transactions through 6/30/00.

Tritium measurement information is contained in Attachment C. The state of the art thermoelectric calorimeter obtained by Berkeley Lab will allow measurements of the tritium inventory to be carried out more completely than has been possible in the past. As with any new technology, development and implementation of the laboratory procedures for use of the calorimeter will require careful planning and research. Information on progress in this area will be available in the future.

Attachment A: Potential consequences of various accident scenarios
Attachment B: Tritium inventory and accountability
Attachment C: Tritium measurement information

Ernest Orlando Lawrence Berkeley National Laboratory
One Cyclotron Road | Berkeley, California 94720 | Tel: 510.486.5514 | Fax: 510.486.7488

Attachment A

Potential Consequences Of Various Accident Scenarios
For Tritium Releases From The National Tritium Labelling Facility (NTLF)

Review of the operational history of the NTLF over the 18-year period since it began NIH funding in August 1982 indicates that there have been no fires, explosions, significant hazardous material releases, nor any significant safety incident.

A comprehensive list of possible accident scenarios was analyzed for preparation of the Safety Analysis Document (SAD) for the NTLF. The scenarios included tritium releases due to accidents during storage and handling of tritium, and from natural disasters (e.g., earthquakes). In all cases, the projected "worst case" public radiation doses are far less than regulatory limits. The analysis of catastrophic accidents from a fire or seismic/landslide event has shown that the accidental releases of tritium inventory cannot cause significant localized consequences. The SAD analysis confirms that the NTLF is a *low hazard facility*.

The accidental scenarios for the potential public exposures are:

Scenario 1: Valve breaks during loading of the tritium bed: Process failure

> This scenario considers that as the uranium bed is being loaded with tritium gas, a valve breaks releasing tritium gas inventory of 2000 Ci to the workbox (only 2,000 Ci of tritium gas is loaded at one time). The total tritium release is into the room and is evacuated through the building exhaust ventilation system and discharged at the exhaust stack. The scenario assumes that 1% of the total tritium release is converted to tritiated water due to heating. The maximum off-site dose is calculated to be 0.21 mrem at the Lawrence Hall of Science.

Scenario 2: Piping to tritium bed sheared during an earthquake: Natural disaster

> This scenario assumes a major seismic event causes the loaded uranium bed to be sheared off from its associated piping immediately after a full load (10,000 Ci) of tritium gas has been adsorbed onto the bed (estimated loss 10 Ci). It assumes 10% conversion of tritium gas to tritiated water due to heating. The resultant release is 1 Ci of tritiated water. This scenario also assumes the ventilation system is not in operation due to the seismic event. The maximum off-site dose is calculated to be 0.5 mrem at the Lawrence Hall of Science.

Scenario 3: Fire causes loss of integrity of tritium bed: Natural or accidental disaster

> The only scenario in which the full tritium inventory could be released from the NTLF is a fully involved facility fire. The scenario assumes that the NTLF is consumed by fire, and the temperature of the tritium storage containers exceeds 600 ^{o}C. The entire inventory of the tritium on uranium beds is released and oxidized, releasing 15,000 Ci of HTO to the atmosphere. The maximum calculated dose is 4.8 mrem at a distance of 1100 meters. (The maximum dose occurs at a further distance for a fire because the fire projects gasses high in the air where the wind carries the maximum deposition hundreds of meters downwind.)

Other mitigating factors to minimize accidental releases of tritium

LBNL staff are well aware that the site is situated near an active earthquake fault, and Berkeley Lab has had a comprehensive earthquake safety program in place since 1973. General seismic requirements are contained in the California Building Code (CBC). Site specific design criteria relating the proximity of the LBNL site to potential adjacent seismic activity is contained in the document "LBNL Design Management Procedures Manual, RD3.22 (Rev. 1, 1996), Lateral Force (Wind and Earthquake) Design Criteria". The LBNL Health & Safety Manual, Chapter 23, outlines a comprehensive seismic safety program which identifies these documents and provides additional criteria for seismic design and construction of structures, systems and components. In addition, LBNL initiated the development of the "Seismic Safety Manual", UCRL-MA-125085, LLNL, 1996. This document provides all DOE facilities with guidelines to prepare their own local requirements with respect to probable seismic activity based on site location. Note that the document "LBNL Design Management Procedures Manual, RD3.22 (Rev. 1, 1996), Lateral Force (Wind and Earthquake) Design Criteria" satisfies the safety guidelines outlined in the Seismic Safety Manual. The Laboratory natural gas system is protected with seismically activated automatic shutoff valves. During a seismic event, ground surface rupture is not expected to occur at LBNL, because actual displacement would occur only along fault traces that are actively involved in the seismic event. The only known fault traces on the LBNL site are inactive and are located a significant distance from the NTLF in Building 75.

Any recent discussion about fires at LBNL usually centers on the devastating Oakland/Berkeley hills fires of October 1991. A large number of mitigating circumstances are often ignored in these discussions: *e.g.*, the LBNL fire department, the generally good access to buildings (*i.e.*, the opportunity for the buildings to be defended against fire), the construction codes used for the buildings, the building fire suppression systems in use at LBNL, the existence of on-site reservoirs (one of which is adjacent to B75), the aggressive vegetation management plan, *etc*.

LBNL designs, builds and operates facilities in accordance with requirements of the CBC, the California Fire Code (CFC), and the "improved risk" concept. This concept is equivalent to fire protection requirements established by fire insurance carriers in the private sector. The concept provides the following protection: (a) minimize the potential for the occurrence of a fire, (b) ensure that fire does not cause an on-site or off-site release of radiological and other hazardous material that will threaten the public health and safety or the environment, (c) establish requirements that will provide an acceptable degree of life safety to DOE and contractor personnel and ensure that there are no undue hazards to the public from fire and its effect in DOE facilities, (d) ensure that process control and safety systems are not damaged by fire or related perils, (e) ensure that vital DOE programs will not suffer unacceptable delays as a result of a fire and its effects, and (f) ensure that property damage from fire and related perils does not exceed an acceptable level. The Laboratory's ability to meet these criteria is immensely assisted by having an on-site Fire Department.

The elaborate fire protection system in place at Berkeley Lab minimizes the possibility of accidental release of tritium due to fire in the NTLF. The fire protection system includes alarms and room sprinklers. To provide a very reliable water supply during emergency conditions, two 200,000 gallon capacity tanks have been installed remotely from each other on the site. A diesel engine driven fire pump has been provided next to each of these tanks. In the event water lines to LBNL are damaged, the 400,000 gallon reservoirs and the two diesel fire pumps on site will maintain water supply and water pressure to each building. As noted above, one of these two on-site tanks is adjacent to Building 75.

Berkeley Lab uses various means to control surface erosion and other earth movements, like landslides. These measures include retaining walls, slope terracing, planned vegetation and paving of footpaths. In fact for decades the LBNL Facilities Department has actively monitored soil movements and mitigated land or mudslides. The site has extensive slope stability drainage systems in place (including hydraugers, monitoring wells and dewatering wells) to address such issues. In past years, a site stability map was prepared, and the area of the site containing Building 75 was considered to be at very low risk of infrastructure damage from soil movement.

Attachment B

Tritium Inventory And Accountability

1. Inventory procedures and documentation

The Nuclear Materials Management and Safeguards System (NMMSS) is the inventory and transaction reporting tool mandated for use by DOE contractors using tritium. NMMSS system procedures can be found in DOE M 474.1-2, Nuclear Materials Management and Safeguards System Reporting and Data Submission, which is available on the internet at http://www.explorer.doe.gov:1776/htmls/regs/doe/newserieslist.html.

Because NMMSS is mandated for use within DOE, it has been maintained complete and up to date in lieu of the unofficial tritium inventory listing which was provided to TIWG. The unofficial inventory listing was prepared as a readily understandable reply to a broad request for information from TIWG; it was a simplified listing compared to the much more complicated material in NMMSS (the NMMSS manual DOE M 474.1-2 itself is 185 pages long). A copy of the NMMSS database listing of LBNL tritium transactions from 12-31-67 to 12-31-99 was provided earlier.

Note that the NMMSS inventory is kept in units of grams, to a precision of 0.01g (96 Ci), where the present conversion factor from grams to curies is 9619 curies per gram. In the past various other conversion factors have been used, namely 9680 Ci/g (historical), 9700 Ci/g (rounded value per DOT), and 10,000 Ci/g (nominal value). Since it is generally unknown exactly which conversion coefficient was used at different times in the past 30 years, this represents a source of uncertainty (~ 3%) in historical transaction data. The reporting threshold for NMMSS transactions is 0.005 g (48Ci); all NMMSS transactions are rounded to the nearest 0.01 g for reporting purposes.

A recent analysis of LBNL tritium inventory and transaction data in NMMSS has shown that the precision of the current inventory figure is most limited by the uncertainties in the tritium content of past waste shipments, i.e. prior to 1996. (There is no disposal of this waste at LBNL.) When radioactive waste is generated it is assigned a nominal tritium content based on process knowledge and historical data. Since 1996, the nominal content values have been partially verified by sampling some or all of the containers. Recent experience has shown that the overall uncertainty in the tritium content of waste has been on the order +/- 25%. Prior to 1996 no QA verification of waste tritium content was required.

Due to these uncertainties, NMMSS inventory data do not have sufficient precision to support mass balance analyses of tritium emissions. To reiterate, the uncertainties in the tritium content of past waste shipments are larger than the amounts of tritium released in emissions. Therefore it would not be meaningful to attempt to use inventory data to validate release measurements. The preferred method of determining amounts of tritium released to the environment is by direct measurements of those emissions. LBNL monitoring systems provide complete and continuous measurements of tritium emissions from NTLF and HWHF stacks with a sensitivity and precision exceeding what would be possible using inventory data. Results of environmental monitoring of emissions are entered into NMMSS as reportable transactions.

While LBNL current estimates of tritium activity in the NTLF and the HWHF agree with the NMMSS balance within the limits of uncertainty, and meet current DOE requirements, improved precision would be desirable to enhance stakeholder confidence. To that end, LBNL is currently procuring a calorimetry system designed to enable accurate measurement of tritium activity on uranium storage and recycling beds. The calorimeter will also be evaluated for use in estimating the tritium content of waste containers, currently the greatest source of uncertainty in the inventory process. The calorimeter system was technically reviewed by the NTLF's Technical and Safety Advisory Committee on 4/13/2000.

2. Inventory update

The NMMSS database listing provided earlier covered transactions dated from 12-31-67 through 12-31-99. The balance on 12-31-99 was 1.47 g (14,140 Ci). NMMSS transactions that have occurred since 12-31-99 are listed below. The balance on 6-30-00, the end of the last calendar quarter, was 1.34 g (12,890 Ci).

Date	Amount (g)	Transaction	Balance (g)
12-31-99		Balance	1.47
3-30-00	-0.02	Roll up entry for emissions: 1997 (41 Ci), 1998 (115 Ci), 1999 (30 Ci)	1.45
3-30-00	-0.02	Decay	1.43
4-7-00	-0.32	Waste shipment to Hanford	1.11
5-8-00	-0.01	Decay	1.10
5-9-00	0.25	LLNL correction to 10-28-98 recycling shipment	1.35
6-30-00	-0.01	Decay	1.34

3. Ongoing accountability

Internal tracking systems to ensure ongoing accountability of tritium inventory at LBNL’s NTLF and HWHF are summarized in the diagram shown below.

This system provides that all LBNL receipts and shipments of tritium (and other radioisotopes used in other laboratories) are managed through the Radioactive Materials Transportation Office (RMTO), including waste shipments. Radioisotopes delivered to LBNL are screened against the ordering laboratory's Radiological Work Authorization to ensure that laboratory is authorized to receive the material, i.e. appropriate administrative and engineering controls, including environmental monitoring, are in place to handle the material safely. All receipt and shipping transactions reportable to NMMSS system are transmitted by the RMTO. Air emissions data from stack monitors are likewise reported to RMTO for reporting to NMMSS. (Tritium discharges to the sanitary sewer have also been, and continue to be, monitored but are too small in quantity to be reported in NMMSS.) Hence, any tritium entering or leaving the Berkeley Laboratory is tracked and accounted for by appropriate inventory procedures.

Attachment C

Tritium Measurement Information

The tritium inventory at the NTLF is tracked using DOE's Nuclear Material Management Safeguards System (NMMSS). NMMSS is used to accumulate and distribute information concerning nuclear materials transactions and inventories per the requirements of the DOE. NMMSS is not designed or utilized to estimate annual facility releases.

To further improve the accountability of the tritium inventory, Berkeley Lab has procured an ultra-sensitive high precision thermoelectric calorimeter. A test method developed using heat flow calorimetry will allow the non-destructive assay of tritium in the tritium storage beds, and will provide a direct measure of tritium content in them. It is also planned to investigate the practicality of using the calorimetry system to measure the amounts of tritium in those waste materials which are the most difficult to quantify. Instrument performance verification and calibrations are underway. Information on progress in this area will be available in the future.

The manufacturer of the calorimeter purchased by Berkeley Lab indicates that the instrument can measure 10,000 curies of tritium with an uncertainty of +/- 100 curies (1%). When smaller amounts of tritium are tested, the measurement uncertainty (as a percent) increases. For example, the uncertainty of measuring 100 curies will be above 1%, and probably close to 10%. The limit of sensitivity of the calorimeter is expected to extend to as low as 10 curies or below; measurements at the millicurie level will likely not be possible.

Note that even with this new technology, the precision in tritium measurements will not support mass balance analysis as a means of validating the amounts of tritium released to the environment. This is because the amount of emissions is such a small fraction of the total inventory. The preferred method of determining amounts of tritium released to the environment is by direct measurements of those emissions. Mr. Bernd Franke, in his preliminary report to the City, agreed with this assessment. LBNL monitoring systems provide complete and continuous measurements of tritium emissions from NTLF and HWHF stacks with a sensitivity and precision exceeding what would be possible using inventory data.